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Circular Cities: Mapping Six Cities in Transition

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ABSTRACT

Urbanisation and climate change are urging cities to chart novel paths towards sustainable futures. Many cities are turning to the alluring 'circular economy' (CE) concept to guide this redirection. The CE concept re-imagines how flows of resources moving through economies might be 'closed'. Here, we explore this new *'circular city'* agenda by asking: *How are cities adopting CE as a strategy*?. We found that political leadership, building adaptable future visions, using experimental approaches (such as living labs), developing contextual knowledge about resource use, and engaging with diverse stakeholders to be important. However, we also expose that there is a lack of consensus on what a circular city constitutes and a need to further untangle the *how* and *why* of the circular city concept. The research contributes to the field by outlining emergent cases, identifying a set of common policy strategies, conceptualising a circular city and identifying areas for future research.

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1. Introduction

Industrial development has brought enormous economic growth, yet hand-in-hand pressure on our planet's resources mounts. Globally, material consumption has grown eightfold over the past 100 years (Krausmann et al., 2009) and is expected to have tripled by 2050 (UNEP, 2011). The likely consequences of this include future scarcity of resources, fertile land, clean water and air (Ellen Macarthur Foundation (EMF), 2012) leading to global price volatility (McKinsey Global Institute, 2011). We know that this system cannot be sustained (O'Neill, 2009; UNEP, 2011).

Cities are mutable 'multi-faceted' entities formed by 'various agents, organizations and networks', perceived by some as increasingly important in the global transition to a sustainable society (Loorbach and Shiroyama, 2016). 75% of global natural resources and 80% of the global energy supply are consumed in cities (UNEP-DTIE, 2012). Urbanisation means nearly 50% of the global population now live in cities and this trend is set to continue leading to 70% by 2050 (UN DESA, 2013). The contributions to and threats of climate change for cities are significant (floods, droughts, storms) and future protection for cities is paramount (Parry, 2007; Rosenzweig et al., 2011). This means that city managers (including policy-makers, urban planners, mayors) can be leveraged and enabled to lead on urban sustainability issues and to tackle climate change at the city-level. Local governments have extensive knowledge of their environment and self-governance and autonomy on urban planning, water, waste and public transportation (Erickson and Tempest, 2014).

Globally, 'circular economy' (CE) principles are being adopted by businesses and governments, as a route to resource efficiency in the face of rising material prices and climate change. The Chinese government, through the CE, aims to maintain

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economic growth while improving environmental quality and maintaining social progress (UNEP, 2016). The European Commission adopted its CE Package, which includes legislative proposals to stimulate Europe's transition towards a CE, to boost competitiveness for sustainable economic growth and jobs (European Commission, 2015). Lately, we see evidence of the CE narrative emerging at the city-level: London's Waste and Recycling Board (funded by the Greater London Authority) is developing a Circular Roadmap[1] and the French environmental agency Ademe has produced a circular city white paper for Paris.[2] CE is interesting at the city-level for a number of reasons. For instance, technical and biological 'nutrients' become aggregated within city boundaries and can be found in quantities worth harnessing through urban mining (Li, 2015). In addition, stakeholders are geographically close and this in itself can aid collaboration to close resource loops (Morlett, 2014).

Nevertheless, the concept of the CE in itself is over-hyped, scarcely investigated and therefore as yet ill-defined. What is somewhat clear is that it is so far dominated by a business-focused narrative for competitive advantage, raising questions about the placement of the CE within a broader urban sustainability agenda. Given that the *circular city* is the latest in a host of urban sustainability trends, that have arguably failed, it should be scrutinized. In this research, we initiate a critical discussion on the concept of the circular city, through six European case studies. The aim is to undertake exploratory research into early examples of city managers initiating CE activities within their cities: *How are cities adopting CE as a strategy*? We review and critique the emerging body of CE literature from an urban sustainability perspective. By examining six cities through semi-structured interviews and desk research we describe the approaches and key activities of each city, leading to an overview of emerging CE cases.

2. Literature review

This section reviews and critiques the literature on the CE from a macro-level (city) viewpoint, as well as how dual approaches (top-down and bottom-up) to urban sustainability can contribute to the CE.

2.1. Urban environmentalism over the years

Since the early nineties, city actors have been forging sustainable development on a regional scale (Bulkeley, 2010). This has given rise to multiple initiatives and alliances uniting mayors and city policymakers, such as the World Mayors Council on Climate Change (WMCCC) and the Cities for Climate Protection Network (ICLEI, 2014). More recently (2005) the C40 Climate Leadership Group was founded, connecting more than 75 of the world's largest cities. Acting as a voice for cities, the organization is focused on "developing and implementing policies and programs that generate measurable reductions in both greenhouse gas emissions and climate risks" (C40, 2015). These organizations focus on environmental challenges including energy transition, transportation, construction, water and waste, inter alia (C40 et al., 2014).

Originating in the 1980s, the concept of 'urban environmentalism', which focuses on redeveloping cities' industrial centers through industrial metabolism projects, is prominent in the eco-cities or eco-towns movement. The related term of 'urban metabolism' considers "*the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy, and elimination of waste.*" (Kennedy et al., 2007, p. 44). Urban metabolism activities range from adapting biomimicry concepts at the city level (Buck, 2015) to unpacking how circular metabolism has been applied to cities (Spiegelhalter and Arch, 2010). Future-oriented eco-cities (Caprotti, 2015) are motivated by the need for knowledge of resources nearing exhaustion (Kennedy et al., 2007) as well as an increasing strain on landfills (Ghisellini et al., 2015), which in combination lead to waste-reduction or zero-waste programs. To this end, Zaman and Lehmann (2013) developed a Zero Waste Index to measure progress on cities' zero waste plans. The zero waste goal was included in European Union policy in 2013 and that initial plan has grown into a comprehensive strategy for a CE in Europe (European Commission, 2015).

The eco-city movement and urban environmentalism concepts have seen some successes, but rely heavily on subsidies and remain too focused on industrial parks and not necessarily yet cities as a whole (Van Berkel et al., 2009). Some successes have been seen, and several 'dense' cities are efficient in terms of their public transport systems (e.g. New York; London) (Newman, 2006), yet there is still much more to be achieved. Notwithstanding this, the paradox is such that 'urbanites' have typically higher environmental impacts than those who do not live in cities (Vergragt et al., 2014) and yet cities can play a role in achieving a more sustainable society overall (Vergragt et al., 2014; Loorbach and Shiroyama, 2016). Loorbach and Shiroyama (2016) implore that radical urban governance strategies are needed to achieve deep systemic change of socio-technical systems and upend unsustainability. Furthermore, this requires that all of the various actors that make up a city (companies, institutions, citizens, Non-Governmental Organisations (NGOs)) must work in concert for long term goals.

The concept of the smart city has been gaining ground for some time and is seen as a vehicle for urban sustainability (Bakıcı et al., 2013; Cocchia, 2014; Bodum, 2015; Caragliu et al., 2011; Hollands, 2008) and more and more as an enabler of CE initiatives (Nobre and Tavares, 2017). Neirotti et al. (2014) describe how new digital capabilities can benefit sustainability through "wise management of natural resources, through participatory governance." The smart city movement is concerned with gathering data to monitor and optimize resource use through technology, a key principle in the concept of CE (EMF,

[1] http://www.lwarb.gov.uk/what-we-do/accelerate-the-move-to-a-circular-economy-in-london/.
[2] https://api-site.paris.fr/images/77050.

2015). Furthermore, a lack of access to data is a key barrier to the implementation of sustainable initiatives in cities and smart city attributes potentially offer ways to address this issue. For instance, by using big data to more efficiently manage waste, water, and energy, improve mobility and building infrastructure (Neirotti et al., 2014). Therein Owen and Liddell (2016) focus on the data requirements related to specific policy interventions in the case of the British city of Leeds. Borghi et al. (2014) show how, in Genoa, Italy, smart city solutions are used towards the implementation of the CE. Yet, the smart city concept is criticized for its blind embrace of technological solutions, its lack of consideration of how this influences human behaviour, as well as the socio-environmental impacts of information and communication technologies on future cities (March, 2016). Furthermore, a lack of technology integration in city infrastructure or limited access to technology, means that some initiatives can be stymied (Neirotti et al., 2014). This means that smart cities are critiqued for exacerbating the inherent biases that technologies create in society (unequal access to communication technologies entrench social divisions).

2.2. Circular economy

2.2.1. Origins of the CE concept

Despite appearing to be very recently foregrounded by key proponents, the CE concept has unfolded gradually. A number of seminal thinkers from the fields of ecology, systems thinking and environmental economics have contributed to its foundations. It describes how the flows of resources, moving through economies on a local, national or global scale, can be 'closed' (Allenby and Graedel, 1993; Chertow, 2000). As early as 1862 Simmonds (p. 366) regretted the need for innovation to generate wealth from waste materials, such as food by-products generated in large towns and cities that become waste due to a lack of systems to capture them. In 1966, economist and systems theorist Boulding drew attention to the physical limitations of the planets' natural resources. Stahel and Reday envisioned an economy of loops based on labour (1976). Frosch and Gallopoulos (1989) described the concept of industrial metabolism as a transformation of the linear economic system into an integrated industrial ecosystem. In turn, this informed Benyus's (1997) biomimicry concept of imitating natural systems for environmental benevolence. More recently, Braungart and McDonough (2009) developed their concept of cradle-to-cradle (as opposed to cradle-to-grave) systems, which promotes the separation of biological from technical materials to recover, reuse or repurpose them. The Blue Economy proposes a systems of multiple cash flows (waste equals value) as opposed to a depletive 'linear' view of value creation (Pauli, 2010). These theories and principles have informed the development of the EMF's recent work to push uptake of the CE in the business community. The EMF communicates an industrial system based on a closed loop, which 'cycles and cascades' resources between industries (as feedstock) to unlock multiple value streams. The EMF's narrative conveys a business-centered view of a CE commensurate with innovation and competitiveness for *commercial* value.

2.2.2. CE models and frameworks

A number of CE frameworks have been developed. The cradle-to-cradle framework (Braungart and McDonough, 2009) describes five criteria; material health, material reutilization, assessment of energy required for production, water usage and social responsibility. The EMF's so-called 'Butterfly Model' draws on the cradle-to-cradle concepts and also depicts a biocycle and a technocycle, describing a series of loops and cascades of materials between stakeholders in the resource cycle (EMF, 2013). Alternatively, Stahel's concept of a utilization focused service-economy (e.g. selling goods as services, stock optimization and focus on utilization) (Stahel, 2010) focus on business models and product design strategies. However, these models are conceptual and simplistic representations of product and materials flows. In its 'Vision for Europe' (EMF, 2015), the EMF sets out viable areas for transitioning Europe towards a CE using an applied definition of the CE and outlining three key principles: preserve and enhance natural capital, optimize resource yields and foster system effectiveness. To underpin these, the EMF describe six business actions that translate these three principles into concrete actions: Regenerate, Share, Optimize, Loop, Virtualize and Exchange (Table 1). This descriptive yet practical framework focuses on CE activity on a macro-level (national/regional/city-level; Ghisellini et al., 2015). Lieder and Rashid (2016) describe a broad integrative CE framework, suggesting a combined top-down (national efforts at societal, legislative, and policy levels) and bottom up approach (company collaborations, supply chain efforts, product design, information and communication technology). This ReSOLVE framework describes how a CE could manifest in a business or political environment, the latter of which is demonstrated by the EMF in its policy toolkit (EMF, 2015). Table 1 highlights CE principles with examples of business activities as well as related sustainability literature.

2.2.3. Limitations of a CE approach for cities

The CE is critiqued for being an incomplete picture based on idealism, a 'partial' approach with 'unrealistic', 'unclear' and 'narrow' goals (Pomponi and Moncaster, 2016; Gregson et al., 2015). A number of contrasting and in some cases contradictory perspectives on the core principles of the CE can be identified in the literature. For example, its origins in industrial ecology is such that it is a primarily macro-level activity (Brennan et al., 2015) yet the contemporary CE literature has predominantly focused on micro-level interventions (e.g. circular product design) (Bakker et al., 2014; Bocken et al., 2015).

The literature shows contrasting views on whether or not the CE should incorporate social dimensions. CE frameworks to-date are criticized by some for sidelining social factors (Murray et al., 2015), indicating that a broader interpretation is needed. However, Pomponi and Moncaster (2016) in a meso-level framework, developed through a meta-analysis, do include societal and behavioural aspects. Hobson and Lynch (2016) stress that considering resource efficiency measures in

Table 1
The ReSOLVE model, adapted from EMF (2015) in context of sustainability literature.

CE principle	Example business activities	Sustainability literature covering these topics
Regenerate	Shift to renewable energy and materials	Braungart and McDonough (2009); Bocken et al. (2014)
	Reclaim, retain and restore health of ecosystems	Braungart and McDonough (2009)
	Return recovered biological resources to the biosphere	Braungart and McDonough (2009)
Share	Share assets (e.g. cars, rooms, appliances)	Cohen and Munoz (2016); Schaltegger et al. (2016)
	Reuse/secondhand	Bocken et al. (2014)
Optimize	Prolong life through maintenance, design for durability, upgradeability, etc.	Bakker et al. (2014); Prendeville et al. (2016); Salvia (2016)
	Increase performance/efficiency of product	Stahel, 2010; Peck et al., (2015)
	Remove waste in production and supply chain	Bocken et al. (2014)
	Leverage big data, automation, remote sensing and steering	Stahel (2010)
Loop	Remanufacture products or components	von Weizsacker et al. (1997)
	Recycle materials	Stahel (1982)
	Digest anaerobically	Pan et al. (2015)
	Extract biochemicals from organic waste	Mohan et al. (2016)
Virtualize	Dematerialize directly (e.g. books, CDs, DVDs, travel)	von Weizsacker et al. (1997); Druckman and Jackson (2010); Meadows et al. (2004)
	Dematerialize indirectly (e.g. online shopping)	von Weizsacker et al. (1997)
Exchange	Replace old with advanced, renewable materials e.g. Mycelium	Lacy and Rutqvist (2015)
	Apply new technologies (e.g. 3D-printing)	Ford and Despeisse (2016)
	Choose new product/service (e.g. multimodal transport)	Stahel (2010)

isolation is detrimental because the complexities of consumer behaviour are poorly understood with respect to new 'circular business models'. Similarly, Pomponi and Moncaster (2016) stress that macro-level CE must take a future-oriented and multidisciplinary approach. However, other studies present the CE as having a narrow remit of municipal waste management (e.g. in the Czech Republic) (Soukopová et al., 2015).

Its legitimacy to benefit the environment is also contested (Andersen, 2007; Allwood, 2014) because materials and energy cannot be cycled ad infinitum without efficiency losses. Over-emphasis on physical resource flows reflects an ambition for resource efficiency rather than environmental preservation (Prendeville et al., 2014). Reijnders' (2008) pans the unscientific basis of the cradle-to-cradle framework by presenting scenarios where natural systems can become suffocated by these same biological 'nutrients'. Similarly, early literature on sustainable cities has also criticized the dominance of techno-centric views in urban sustainability, where measures and flows have been over-emphasized, to the detriment of political debate on what *true* sustainability in cities means (Bulkeley and Betsill, 2005).

The CE agenda pointedly reaches out to businesses, increasing their 'competitiveness' by 'valorising waste' for 'circular advantage' and 'value creation' (Lacy and Rutqvist, 2015), reflecting the 'growth is good' narrative of the cradle-to-cradle framework (Braungart and McDonough (2009). Despite targeting businesses, in reality very few companies voluntarily take-up producer-led CE activities. The ReSOLVE framework encompasses a diverse range of potential business activities including 'sharing'. The sharing economy has been criticized as having a perhaps misleading 'socially-progressive rhetoric' when in fact not all sharing initiatives are beneficial for the environment and its user base comprises a narrow demographic (Frenken and Schor, 2017), which could never represent the diversity of citizens and communities in a city. Similar criticisms can be made of the CE. Advocates for circular business models (such as the 'access' model) place increasingly more control with businesses and erode citizen autonomy. Furthermore, the application of CE principles in businesses is a vastly different endeavour to the adoption of CE in cities. Businesses are risk averse, have vested interests in things like intellectual property that can limit progress and are principally focused on profit-making.

Cities are first-and-foremost places for people and their sustainable futures. In any conceptualization of a circular city these issues require consideration. Notwithstanding this, '*knowing what to do and how to act*' (Vergragt et al., 2014) is a challenge due to the manifold perverse issues in public governance. For instance, progressing through smart circular cities, when both constructs are critiqued to forego social good could lead to mutually reinforcing biases. Nevertheless, with the CE's high profile and capacity to engage a multitude of stakeholders, alongside the growing recognition of the importance of cities for addressing sustainability (ICLEI, 2014), there is a need, as well as an opportunity, to gain understanding of what a potential future circular city constitutes.

2.3. Top-down and bottom-up change

In the context of the CE, a number of frameworks convey a dichotomy of bottom-up and top-down initiatives (e.g. Lieder and Rashid, 2016; Pomponi and Moncaster, 2016; Ghisellini et al., 2016). Lieder and Rashid's (2016) CE framework conveys bottom-up as the 'business community' whereas Pomponi and Moncaster (2016) emphasize the role of grassroots

Table 2
The circular city policy intervention types adapted from EMF (2015).

Strategy	Description
Knowledge development	Knowledge development is an adaptation on the EMF policy intervention type: education, information and awareness. This type of project is seen often in pioneering cities and often involves collaboration with a knowledge institute (e.g. university). The goal of the project is to gather information or develop knowledge on CE, material flows, citizen activity or anything relevant to policymakers or businesses for transitioning to a CE.
Collaboration platforms	Large cooperatives between stakeholders such as between government, businesses and knowledge developers, but can also be industry specific. Their goals (from a policymaker's perspective) are to develop understanding of the needs of partners, and to leverage the partners' expertise and networks.
Business support schemes	Business support schemes are projects, usually developed by the city's policymakers or by local corporate partners that aim to support local businesses and entrepreneurs in developing innovative (CE) business proposals or to further (circular) start-ups. Business Development Schemes in cities often include fiscal frameworks where project funding goes hand in hand with business support.
Regulatory frameworks	Regulatory frameworks are projects or activities where policymakers use its rules and regulations in order to facilitate businesses, knowledge developers, citizens or collaboration platforms in developing CE in the city.
Procurement and infrastructure	Procurement and infrastructure projects are projects where the policymakers use its purchasing and tendering power to further CE development.
Fiscal frameworks	Fiscal frameworks are generally a national policy intervention and focus on creating fiscal incentives for a CE; such as increasing taxes on virgin materials, lowering taxes on labour, CO2 taxes and increasing taxes on incineration or landfill. On a city scale, however, these frameworks are less relevant as their focus is mainly on national legislation and regulation.

communities and citizens who, by leading sustainable lifestyles, engaging in co-creating futures visions and participating in governance, play a role in urban sustainability (Vergragt et al., 2014). Furthermore, bottom-up innovation has been discussed as a way to address climate change for many years (Bergman et al., 2010; Verheul and Vergragt, 1995). Bottom-up innovation encompasses the business community as well as networks and groups creating innovative solutions for sustainable development that respond to local scenarios (Smith and Seyfang, 2007). Examples include community-driven energy programs (Forrest and Wiek, 2014; Seyfang et al., 2014; Van der Schoor and Scholtens, 2015), civic low carbon labs (Heiskanen et al., 2015), creative maker-networks like Fab Labs (networks of workshops that provide (public) access to tools and skills) (Kohtala and Hyysalo, 2015; Stacey, 2014); or repair and reuse networks (where people can share goods or help one another fix goods) shows community competence for energy and waste management. Relevant to the concepts of a circular city is that of the grassroots global community Open Source Circular Economy.[3] It is developing and implementing 'local actions' as part of its circular city[4] collaboration with the EMF. This includes developing: local food policies, an application to provide information about reparability of products to citizens; and establishing a community currency.

Despite a case for these initiatives, bottom-up action is constrained by regulatory, political and infrastructural barriers (Bergman et al., 2010). Therefore, for the purposes of this study, we acknowledge the complementarity of bottom-up and top-down interventions, taking the view that policymakers should play a role in stimulating bottom-up business, citizens and communities for urban sustainability. Understanding the types of top-down interventions policymakers utilize to move towards a circular city could offer valuable lessons to other policymakers. Here, we draw on the EMF's 'Toolkit for Policymakers', which outlines six policy intervention types that can be employed by policymakers to overcome barriers in implementing CE activities: education, information and awareness (knowledge development), business support schemes, collaboration platforms, public procurement and infrastructure, regulatory frameworks and fiscal frameworks (Table 2).

2.4. Research gap

Research on urban sustainability to date has focused on 'eco-cities' (Van Berkel et al., 2009), zero-waste cities' (Zaman and Lehmann, 2013), 'smart cities' (Caragliu et al., 2011; Hollands, 2008), and specific approaches such as biomimicry (Buck, 2015). In a comprehensive bibliometric analysis De Jong et al. (2015) identify twelve distinct yet similar concepts relating to urban sustainability from 'sustainable cities', and 'green cities' to 'eco-cities' highlighting a range of viewpoints. Notwithstanding the CE concept's increasing use in practice by policymakers, De Jong's study did not identify the topic of circular cities illustrating a lack of attention to the subject in the literature so far. Furthermore, De Jong asserts that urban sustainability agendas require both rigour and nuance to be truly beneficial for urban sustainability.

[3] https://oscedays.org/.
[4] https://oscedays.org/dif-labs-2016/.

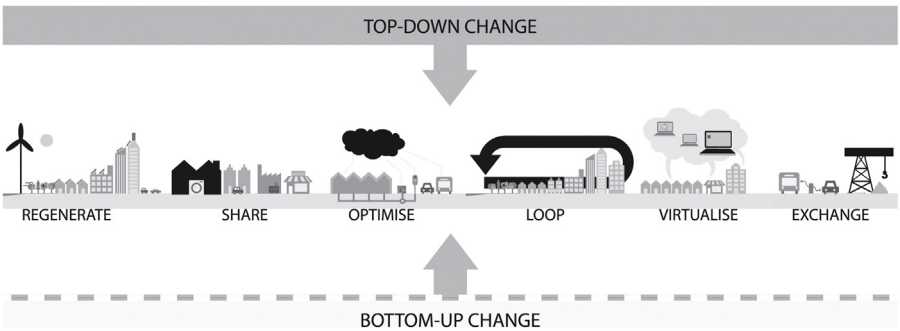

Fig. 1. The circular city framework, adapted from the ReSOLVE framework (EMF, 2015).

Nevertheless, some research on CE in cities has been undertaken. So far, this body of work takes a Chinese viewpoint and mainly focuses on industrial eco-parks (Chang and Sheppard, 2013; De Jong et al., 2013; Geng et al., 2009; Vergragt et al., 2014). For instance, Yu et al. (2015) describe the use of CE labels in a narrow context, as voluntary incentives, used during the transition from eco-industrial parks to eco-city plans, but also describe the confines of the CE approach studied. The authors criticize the limited scale of the initiatives, instead calling more long-termism and systematic approaches to the implementation of CE policies and regulations, which are seen as being critical to success. Similarly, Geng et al. (2009) identify barriers to CE in the Chinese city of Dalian including a lack of public awareness and participation and a need to broaden the remit of CE activity. This echoes earlier literature on urban sustainability that calls for future-oriented, multidisciplinary and integrative approaches. Understanding local contexts is important for effective policy interventions (Van Bueren and ten Heuvelhof, 2005; Geng et al., 2009) and therefore insights from a European perspective on urban CE are needed.

In the existing literature, the implementation of CE in cities is ambiguously understood, but this research has found that cities themselves self-identify with the concept (Bosch, 2015; City of Amsterdam, 2013; Glasgow Chamber of Commerce et al., 2016; Metabolic et al., 2015). This is likely because, with the exception of Su et al.'s (2013) study on Chinese cities, the discussion on CE has rarely been discussed from an implementation angle (Lieder and Rashid, 2016). Despite criticism of the CE concept (idealistic, not linking up to normative expectations, no social considerations) the CE has clearly been adopted as an aspirational concept by several cities (City of Amsterdam, 2013; Glasgow Chamber of Commerce et al., 2016; Metabolic et al., 2015). Furthermore, it is possible that through a future-oriented multidisciplinary and systemic view (Van Berkel et al., 2009), the CE can benefit economic as well as social issues in unison.

A number of CE models and frameworks have been identified in the literature (Lieder and Rashid, 2016; Braungart and McDonough, 2009; Stahel, 2010; Bocken et al., 2015). However, their scope is specific, they are largely conceptual and lack transferability to a city context. In addition, many of the frameworks developed to-date focus on micro-level activities (manufactured goods e.g. Bakker et al., 2014), meso-level (buildings e.g. Pomponi and Moncaster, 2017), whereas studies on macro-level CE activities (i.e. cities) are few. This in itself appears inconsistent with the foundations of the CE approach as described in Section 2.2.1.

Hence, there is a need for empirical data on the topic of the circular city. Therefore, to bridge this gap, this study initiates exploratory research on how cities are adopting CE in their strategies.

2.5. Conceptual framework: the circular city

Here we describe a conceptual framework of a circular city (Fig. 1) based on the literature review. The purpose of this framework is to provide a lens through which to understand the ways CE could manifest in a city. For the purposes of this study, we acknowledge the (somewhat mutable) complementarity of bottom-up and top-down interventions. However, bottom-up initiatives are harder to identify and can be hyper-local with only a small group of individuals actively participating in initiatives. Here we take Bergman et al.'s (2010) view that policymakers should play a role in stimulating bottom-up business, citizens and communities activities for urban sustainability.

- ***Top-down change*** is institution-driven (in this case municipal/local government) change such as strategy and policy decisions including public-private partnership projects concerned with developing and facilitating market initiatives (Krauz, 2016; Pomponi and Moncaster, 2016; Ghisellini et al., 2015; Lieder and Rashid, 2016).
- ***Bottom-up change*** describes social movements and social innovation such as initiatives and entrepreneurial activities initiated and run by civil society, NGOs, communities and businesses (Krauz, 2016; Pomponi and Moncaster, 2016; Ghisellini et al., 2015; Lieder and Rashid, 2016).

The framework builds on the CE principles described in the EMF's ReSOLVE framework (Table 1), adapted to encompass urban activities instead of business activities. The expanded version of the circular city framework is shown in Table 3, which elaborates on each of the six ReSOLVE principles to generate a set of circular city principles.

Table 3
Circular city principles explained – adapted from the ReSOLVE framework (EMF, 2015).

Circular city principle	Top-down example	Bottom-up example
Regenerate	Utilizing rooftops as solar fields, developing green space for biodiversity and to improve air quality.	Personal acquisition of renewable energy; solar panels, urban farming, electric or biogas fuelled mobility.
Share	Policy innovation to support the collaborative economy, regulate sharing, tax and fiscal measures incentivizing sharing.	Car sharing, appliance sharing (washing machines, tools), repair (repair cafes), reuse (clothing, furniture, vehicles, appliances).
Optimize	By using gathered data on traffic flows, the efficiency of cities' major transportation can be optimized, decreasing congestion. Installing smart LED lighting throughout the city to save energy. Retrofitting old buildings to increase their energy efficiency.	Smart citizen labs, Fab Labs, smart grids, smart communities.
Loop	Waste separation and recycling, district heating, bio-based economy, reverse logistics.	Community recycling initiatives, upcycling initiatives, community bio-digesters.
Virtualize	Virtual city hall counters. Autonomous public transportation and semi-private transportation like taxis. Virtualization of public libraries, archives, legal information. A paperless municipality.	Community-led digital platforms, citizen-science climate monitoring.
Exchange	Circular construction/demolition materials and processes, electric powered public transportation, procurement of circular office furniture.	Electric mobility, organic and locally-sourced (super)markets, eco-fashion, e-readers.

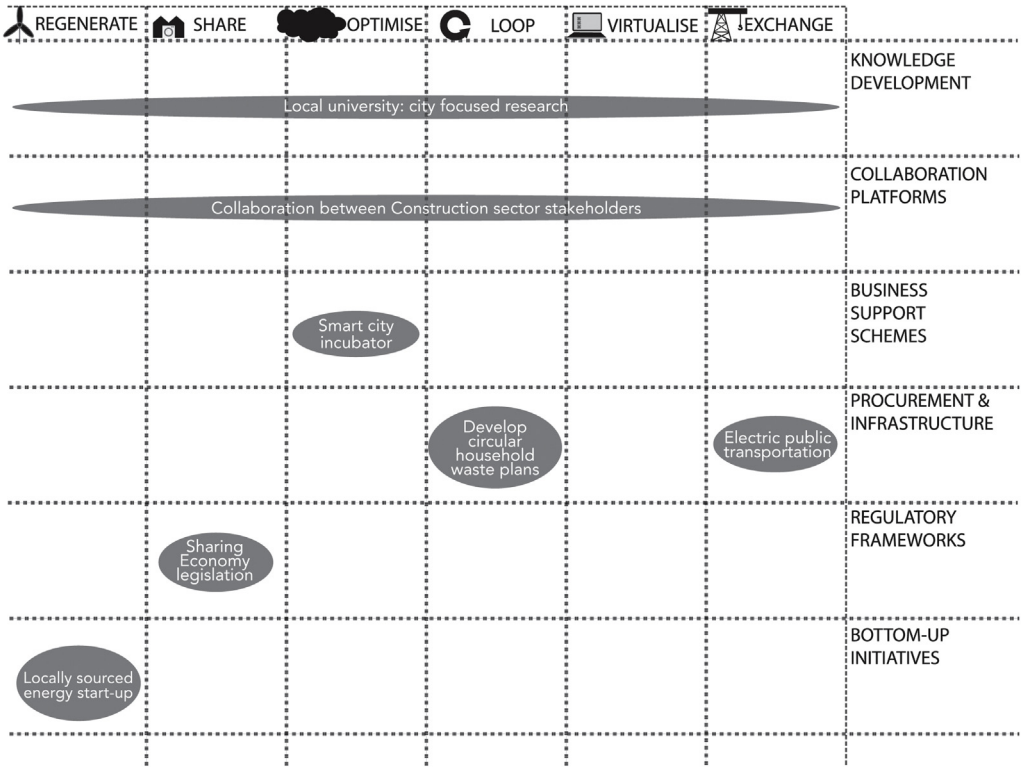

Fig. 2. Circular city project map adapted from circular city framework and EMF (2015) with examples.

3. Methodology

This section describes the methodology. Using the conceptual framework (Fig. 1), six cities are examined through qualitative case studies. The conceptual framework was validated through interviews and expanded on to create a circular city project map (Fig. 2).

3.1. Case study research

An accepted way of inducting theory from qualitative information, embedded in practice, is through case studies (Yin, 2009). Case study research is often used in new topics (Eisenhardt, 1989) and when one is attempting to explore and

Table 4
Experts interviewed for insights on conceptual framework.

Organization	Title	Type of interview
AMS Institute	Project Manager Research	45 min face-to-face
Circle Economy	Circular Developer	One hour face-to-face
City of Amsterdam	Senior Advisor sustainability strategy	One hour face-to-face
	Program Manager Urban Innovation	One hour face-to-face
Amsterdam Smart City	Project manager online strategy	30 min face-to-face

Table 5
Excerpts illustrating validation of the circular city framework and circular city project map.

Validation	Example excerpt
Relevant	E1: "[B]ut also what are the tools, what is a local government's toolbox, what are the leverage points for a local government to grab on to this, because that transcends projects, those are just the results of what you to steer towards."
	E2: "As a communication tool this model is super interesting"
Usable	E3: ". . .You're taking real action, all of this [circular city framework] to me, and that's what I really like about it, is taking real action towards circularity."
Comprehensive	E4: [referring to circular city principles] "This one is interesting. . . and this one. . . and this one. . .. Really all of them are."
Comprehensive and relevant	E5: "[B]ut nobody's answered it yet. This [circular city framework] out of all the things I've seen, I really like this, what you've done. . . . Yeah, it's nice."

understand, rather than to quantify and confirm. Given that the cities undertaking CE activities are novel and emerging, case studies are deemed appropriate to investigate this phenomenon.

3.2. Validation of the circular city framework and project map

Exploratory interviews with Amsterdam policymakers were undertaken to validate the relevance, comprehensiveness and usability of the circular city framework and circular city project map. Amsterdam's city managers were chosen due to their leadership in adopting circular initiatives. For example, it has adopted a 'Nederland Circulair'[5] initiative supported by the Dutch Ministry of the Environment and Infrastructure, which seeks to position the Netherlands as a globally leading CE hotspot. Interviewees are listed in Table 4 and interview excerpts to validate the frameworks can be found in Table 5.

The interviewees expressed a need to understand what CE means in practical terms and what their leverage points are. In this capacity, the map and framework were appreciated for their relevance and usability. Policymakers were struggling to envision practical CE actions and by discussing the framework and map they expressed appreciation for the practical guidance that such tools can offer.

3.3. The circular city project map

The circular city framework defines the different CE principles a project may focus on. To develop a policy-relevant analytical framework, policy intervention types are integrated (Fig. 2). This allowed the research team to map circular city projects against circular city principles, as well as the type of policy intervention used to establish the project. The horizontal axis includes the circular city principles from the circular city framework and the vertical axis lists the policy intervention types (Fig. 2). Some projects can be assigned to one circular city principle (e.g., *share*) and correspond to one policy intervention type (e.g., *regulatory frameworks*). On the other hand, some projects correspond to one policy intervention type, such as *knowledge development*, but span all circular city principles.

Cases were constructed and analysed through three types of data: documents, project mapping, and interviews.

- ***Document review***: Documents such as sustainability agendas and environmental programs were reviewed to establish an understanding of each city's sustainability goals and CE strategies. Additionally, bottom-up change was discussed with the interviewees, to foster a more integrative view of how CE is developing in cities.
- ***Projectmapping***: Projects and initiatives in those cities that are starting to implement their visions were mapped against the ReSOLVE criteria and the types of policy approach being used. This was undertaken in collaboration with the participants. While this is not intended to be exhaustive, this mapping exercise informs the individual and cross-case analysis and this was supported with desk-research.
- ***Semi-structured interviews***:At least one actor from each city was interviewed providing insight into the way these cities approach CE as well as the activities underway. This ensures that the information collected is comparable but also allows for an interviewer to follow an interesting line of questioning (Kvale and Brinkmann, 2009).

[5] http://www.circulairondernemen.nl/.

Table 6
Criteria for case selection.

Criteria	Determined by
Clear intent to develop a CE	Examining published statements, included CE in on- and offline documentation, published agenda's, etc.
Have taken identifiable steps towards a CE	Based on interviews with experts, recommendations by experts, project websites and publications.
Availability/ability to cooperate	Ability to identify stakeholders and initiatives who are knowledgeable about the CE activities.

3.4. Case selection

Cases were selected according to criteria established based on preliminary desk research into CE in cities in Europe (Table 6). Six cities were studied including four cities that are in the preliminary phase of implementing CE strategies (Amsterdam, Rotterdam, Haarlemmermeer, Glasgow). The cases of The Hague and Barcelona provide insight into early stage cases. Due to the characteristics of the cases of The Hague and Barcelona, which are both early stage cases, project maps were not developed for these cities. The cases were selected for their opportunity to learn about early steps being taken by cities.

Table 7 describes the cases selected, and Table 8 describes the interviewees per city.

Table 7
Selected cases.

Case	Selected because
Amsterdam (Dutch capital, population = 800.000, average income/household = €31400)	Published CE strategy, several real-estate projects including CE plans, large number of community-owned CE initiatives. Multiple knowledge development projects concerning CE (including development of independent institute for urban sustainability research).
Rotterdam (population = 600.000, average income/household = €31600)	Published comprehensive sustainability strategy including CE- and bio-based economy plans. Large number of community-owned CE initiatives, mostly bio-based. Strong involvement with Port of Rotterdam for CE. Serious commitment to developing CE further by commissioning celebrity economist to create CE future vision.
Glasgow (population = 600.000, average disposable income/household = €39,400)	Scottish government shown large commitment to developing CE through Zero Waste Scotland. City council published sustainability strategy. Chamber of Commerce commissioned Circle Economy (circular consultants) to perform extensive research on material flows and potential of CE.
Haarlemmermeer (population = 144.000, average income/household = €39400)	Published a 'scenario study' exploring future challenges and extensive sustainability agenda with accompanying project plans. Strong involvement with Schiphol Group (airport in region) creating an interesting dynamic. Member of the EMF's CE100 group.
The Hague (population = 520.000, average income/household = €32600)	Chosen as a city that has not yet made progress or taken concrete steps towards a CE. Recently (2015) published their first sustainability agenda and are currently in the process of taking an inventory of smaller CE projects, initiatives and enthusiasts within the organization.
Barcelona (population = 1,600.000, average income/household = €22101)	Barcelona has taken a lead in developing a smart city, through a top-down and comprehensive master plan. It has also been a pioneer in exploring the concept of a Fab City, for local urban production systems (e.g. food, energy).

Table 8
Interviewees per selected city.

City	Role	Type and duration of interview
Amsterdam	Program Manager Urban Innovation (Public Servant)	One hour, face-to-face
	Strategic Advisor Sustainability (Public Servant)	One hour, face-to-face
	Circular Developer (CE consultant)	One hour, face-to-face
	Operations manager (CE designer/consultant)	30 min, face-to-face
Rotterdam	Project Manager Urban Development (Public Servant)	One hour, face-to-face
Glasgow	Strategic Advisor Chamber of Commerce	One hour, face-to-face
Haarlemmermeer	Urban Designer (Public Servant)	One hour, face-to-face
The Hague	Program Manager Sustainability (Public Servant)	One hour, face-to-face
Barcelona	International Connector Ouishare Community	One-hour (skype)

	Re	S	O	L	V	E	
A1: Circular Economy City Scan				●			Knowledge Development
A2: City Dashboard					●		Knowledge Development
A3: Pakhuis de Zwijger	●	●	●	●	●	●	Knowledge Development
A4: AMS Institute	●	●	●	●	●	●	Knowledge Development
A5: Construction Green Deal				●		●	Collaboration Platforms
A6: Circular Area Buiksloterham	●	●	●	●	●	●	Collaboration Platforms
A7: Metro Region Amsterdam Industrial Park	●	●	●	●	●	●	Collaboration Platforms
A8: The Ceuvel Sustainable Community	●	●	●	●	●	●	Collaboration Platforms
A9: Amsterdam Smart City			●				Business Support Schemes
A10: Sustainability Fund	●	●	●	●	●	●	Business Support Schemes
A11: Amsterdam Economic Board	●	●	●	●	●	●	Business Support Schemes
A12: CTO Office Start-up in Residence	●	●	●	●	●	●	Business Support Schemes
A13: Sharing Economy Legislation		●					Regulatory Framework
A14: Retrofitting			●			●	Procurement & Infrastructure
A15: Alliander Smart Grid			●			●	Procurement & Infrastructure
A16: District Heating				●			Procurement & Infrastructure
A17: "Free-zones" Living Labs	●	●	●	●	●	●	Regulatory Framework
A18: Building Renovation Standards			●			●	Regulatory Framework
A19: Circular Procurement						●	Procurement & Infrastructure
A20: Household Waste Plan				●			Procurement & Infrastructure

Fig. 3. Initiatives identified in Amsterdam.

4. Results

This section describes the results from the case studies of Amsterdam, Rotterdam, Glasgow, Haarlemmermeer, The Hague, and Barcelona. This is followed by the cross-case analysis. The cases include views from the interviewees and a selection of those initiatives identified are discussed for each city. A full description of each project can be found in Appendix A.

4.1. Amsterdam

The Dutch 'Nederland Circulair'[5] initiative established in 2015 by the city alderman opened up opportunities to invest in CE activities. CE is written into the Amsterdam sustainability agenda, which also includes energy, climate-change resilience and air-quality. Since then, Amsterdam's Strategic Advisor for Sustainability stated that a full action program with 'circularity' as a key aspect was making the CE agenda a powerful one.

Policymakers take a cross-sectoral interpretation of CE and the city's strategy covers all the circular city principles outlined in the ReSOLVE framework. The project map (Fig. 3) shows that a fairly even balance across policy measures is taken, with procurement and infrastructure being used for specific areas, whereas collaboration platforms, business support schemes and knowledge development activities address many. For example, the AMS Institute is an important research and institutional partner, focused on developing sustainable solutions for metropolitan issues. Similarly, the Dutch CE consultancy 'Circle Economy' plays a central role in the city's CE activities. It has supported benchmarking research on the city's physical resource flows (using its circular city mapping tool,[6] city scan and city dashboard) giving policymakers information to manage the city's resources effectively (Circle Economy et al., 2015).

Policymakers express nuanced visions for CE and appreciate its complexity. Despite of, or perhaps because of, its pioneering position, Amsterdam's Strategic Advisor for Sustainability admits that there needs to be space for "*experimentation*", because it is a new area for them and "*some things [about CE] we really just don't know yet*". It was mentioned that "*at the moment we have limited (policy) instruments, but at least we have some*" (interview Strategic Advisor for Sustainability). For example, the way of financing is opportunistic: "*we want to go where there is energy and give existing projects a boost and stimulate these by using our policy instruments such as through our sustainability fund*" (interview Circular Program Manager). In addition, policymakers discuss the concept of a "future-proof" city (rather than a sustainable city per se).

Numerous experiments are underway in the city. An experimental approach can be seen for instance in the legislative "free-zones" implemented in the decaying post-industrial area of Buiksloterham, where partners can experiment with waste collection and water sanitation approaches. Similarly, in 2016 Amsterdam became a Fab City,[7] exploring the potential for

[6] http://www.circle-economy.com/cities/.
[7] http://fab.city/.

	Re	S	O	L	V	E	
R1: Green Waste Streams				●			Procurement & Infrastructure
R2: Biobased Delta (1)				●			Knowledge Development
R2: Biobased Delta (2)	●	●	●	●	●	●	Collaboration Platforms
R3: Blue City Sustainable Community	●	●	●	●	●	●	Collaboration Platforms
R4: Rotterdam Climate Initiative	●	●	●	●	●	●	Collaboration Platforms
R5: City Lab 010	●	●	●	●	●	●	Business Support Schemes
R6: Circularity Centre	●	●	●	●	●	●	Business Support Schemes
R7: Project Rosa				●			Procurement & Infrastructure
R8: Large Scale District Heating	●						Procurement & Infrastructure
R9: IABR Urban Metabolism				●			Knowledge Development
R10: Jeremy Rifkin Future Vision	●	●	●	●	●	●	Knowledge Development
R11: Better Future Factory	●	●	●	●	●	●	Business Support Schemes

Fig. 4. Initiatives identified in Rotterdam.

a new city dynamic, through distributed urban production systems, enabled by new technologies such as 3D printing and smart and efficient mobility and food systems. Similarly, a fully circular community called "De Ceuvel" is situated in the city. It is a participatory living lab of a self-sufficient community, which aims to be 'at the vanguard of circular living' (Metabolic, 2015). This includes residents constructing self-build homes from recycled materials and managing its own material, energy and food flows. This initiative is driven by a 'Manifesto for a Circular Buiksloterham' of which 'circular, bio-based and smart' are key themes (Metabolic et al., 2015).

4.2. Rotterdam

Rotterdam's policymakers consider CE to be a tool to create sustainable and innovative *business*. It is listed as one of five points to achieve its goal of creating a strong economy (Gemeente Rotterdam, 2015). The CE and bio-based economy are prominent in its recently published sustainability agenda and the municipality has published its vision for the future of Rotterdam (Gemeente Rotterdam et al., 2014).

In Rotterdam, making initiatives visible is seen to have a ripple effect of scaling innovative solutions. For instance, Rotterdam's Project Manager for Urban Development mentioned its portfolio of projects to put the city's vision into action, including specific agreements with companies to keep the agenda active and generate further funds for new projects. Important challenges for the urban designer include visibility, scalability and connections: "*. . . we do a lot of innovations: how to make these visible? That's quite a challenge. (. . .) All those innovations in sustainability, biomass, circular, sustainability, what happens in the port and city, and the connections between those; making small things bigger, . . . You can see this transition . . . Then you can get a new perspective, and from this new perspective you can drive the economy and keep politics and management sharp and involve companies.*" (Project Manager Urban Development). Perhaps because of this drive for visibility, in an idiosyncratic move, the city council commissioned Jeremy Rifkin[8] to co-develop a vision for the city's future. Through this visibility, they hope to motivate other parties in the area to also find creative ways to generate new value. Examples include Better Future Factory's 'circular upcycle tool', developed to create tiles from waste, or through City Lab 010, which acts as a collaboration platform to connect and fund partnerships.

The project map (Fig. 4) shows how business support schemes and collaboration platforms are used to broadly incentivize whereas procurement and infrastructure and knowledge development activities can be more focused. Rotterdam has been working in collaboration with the Port of Rotterdam (Europe's largest port) in particular on bio-based projects, as well as constructing several Green Deals. The bio-based economy is promoted and large areas in the port and the city have been committed (by the Port of Rotterdam) to bio-based economy activities (Gemeente Rotterdam, 2015). For example, the Bio-based Delta alliance focuses on three key pillars of activity: green raw materials; green building blocks and greening the processing industry. Community-led initiatives are identified too, such as the Blue City and pilot projects are underway, such as the 'green waste stream' that are trying to find options for garden waste reuse.

4.3. Glasgow

In 2002, the Scottish government published its first sustainability strategy. Since 2007 environmental targets such as an 80% reduction in greenhouse gas emissions by 2050 are in place. In 2009 the Climate Change (Scotland) Act was passed and in 2010 Scotland's Zero Waste Plan was published, leading to the establishment of Zero Waste Scotland a government funded

[8] American economist and expert on sharing economy and Internet of things.

	Re	S	O	L	V	E	
G1: Future City Glasgow	●	●	●	●	●	●	Knowledge Development
G2: City Dashboard			●		●		Knowledge Development
G3: Circle City Scan				●	●		Knowledge Development
G4: Annual Scottish Resources Conference	●	●	●	●	●	●	Knowledge Development
G5: Open Glasgow (Engagement)	●	●	●	●	●	●	Knowledge Development Business Support Schemes Collaboration Platforms
G6: Green Glasgow	●		●			●	Collaboration Platforms
G7: Scottish Institute for Remanufacturing	●	●	●	●	●	●	Collaboration Platforms
G8: Zero Waste Scotland				●			Business Support Schemes

Fig. 5. Initiatives identified in Glasgow.

organization that aims to drive change towards a waste-free country. Therefore, the mission is put forward from national government and Glasgow is developing knowledge to pull the transition. In Glasgow, the strategy is to collect information and develop knowledge to enable Glaswegian businesses to develop circular propositions and business models and therefore there is an emphasis on collaboration platforms and knowledge development initiatives (Fig. 5).

To create understanding of urban material flows, the Glasgow Chamber of Commerce commissioned the same Amsterdam-based consultancy (Circle Economy) to perform their *City Scan* to develop a vision and an action plan for developing CE (Glasgow Chamber of Commerce et al., 2016) and this is to be closely integrated with the Glasgow Digital Plan (through the city dashboard). In 2013, Future Glasgow, an open data platform that "uses data and technology to make life in the city safer, smarter and more sustainable", was initiated. This includes, for example, mapping the city's site potential to develop renewable energy, or monitoring energy use to identify potential gains of retrofitting energy in different types of Glaswegian homes. Open Glasgow (an open data initiative) supports this and shows a focus on digital knowledge and making data insightful, for manufacturing opportunities and wider industry.

In Glasgow, a focus combining social, environmental and economic aspects of the CE is conveyed: "*[T]he quality of life in terms of the environment that people work in, [the] space and the quality of life of the citizens of the city, that's a huge component of the move. . .. So from litter use, just better use, more efficient use of the city and the resources of the city, so that people can enjoy their life better, so that could be in terms of waste that's collected, more green spaces, less traffic. . .you're improving the quality of life and the economy*" (Strategic Advisor, Chamber of Commerce). However, the interviewee also conveyed a centralized approach and stated that involving individuals and companies is perceived as challenging. "*. . .it's not the kind of thing where you can have it beautifully wrapped in a chart. . .there isn't an absolute answer. . .you could be really radical*" (Strategic Advisor, Chamber of Commerce).

Involving business is recognized as essential: "*how do you grow a city's economy and benefit the city through circularity*" (Strategic Advisor, Chamber of Commerce). The Glasgow Chamber of Commerce in conjunction with the city council have created the Green Business Network to support and connect businesses. The Scottish Institute for Remanufacturing was founded in 2015, funded by Zero Waste Scotland and is hosted at the University Strathclyde, which aims to co-fund collaborative projects that enable reuse, repair and remanufacturing. Remanufacturing is estimated to have a high potential due to the shape of Scottish Industry (high value machinery from industries like oil and gas) and the CE is a foremost lever within Scotland's manufacturing strategy to 2020. However, this is not straightforward: "*[O]ne of the biggest challenges [is] to make [CE] simple and understandable and see where [and] which bit people can really contribute or get involved in, which is most relevant for them as an individual or as a company or as a public sector organization, which areas can they interface in and make a difference*" (Strategic Advisor, Chamber of Commerce).

4.4. Haarlemmermeer

The Dutch municipality of Haarlemmermeer is a region with challenging characteristics. The presence of Schiphol airport, an international hub, has a large impact on the region and is a powerful local actor. In 2015, the city set ambitious and specific CE goals, accompanied by a collection of early stage projects. CE and sustainability are relatively new agendas taken up by the municipality and are being pulled by one key city alderman responsible for environment and infrastructure, John Nederstigt. He joined the municipality in 2010 and since then has driven the sustainability agenda forward. Yet there is uncertainty about whether recent efforts will maintain momentum. Through the interview the need for a more long-term vision of what their municipality might look like in the future was expressed and this is an ongoing process (interview Urban Designer).

The urban designer sees CE as a tool through which to create a high-quality living environments, emphasizing knowledge development to kick-start its circular city activities. The interviewee described the complexities around implementation of certain CE initiatives, "*Sharing is not only about raw material and energy exchanges but. . .about knowledge and. . . we still have a mega job to do there (. . .), not only as the local government, but also in the relation between the government and business and*

	Re	S	O	L	V	E	
H1: Groen in de Klas	●						Knowledge Development
H2: Biobased Expo Centre				●			Knowledge Development
H3: Arizona State University Partnership	●	●	●	●	●	●	Knowledge Development
H4: Beyond Sustainability Group	●	●	●	●	●	●	Collaboration Platforms & Knowledge Development
H5: EMF Membership	●	●	●	●	●	●	Collaboration Platforms
H6: De Groene Kapstok			●				Collaboration Platforms
H7: Green Deal Gras & Gewas				●			Collaboration Platforms
H8: SHARE Haarlemmermeer	●	●	●	●	●	●	Collaboration Platforms
H9: Meermaker Participation Fund	●	●	●	●	●	●	Business Support Schemes
H10: ENGINN Incubator	●	●	●	●	●	●	Business Support Schemes
H11: Sustainable Procurement Guidelines						●	Procurement & Infrastructure

Fig. 6. Initiatives identified in Haarlemmermeer.

science" (Urban Designer). To this end, the interviewee discussed the 'quadruple helix' and described knowledge exchange as essential to solve the big challenges. First, Haarlemmermeer wants to create CE experiments with companies and the government (the triple helix – business, government, knowledge institutes), and eventually include citizens/society with a "quadruple helix approach" (interview, Urban Designer).

A selection of projects from Haarlemmermeer are shown in Fig. 6 (Gemeente Haarlemmermeer, 2015). These projects show a very broad interpretation, from public-private collaboration platforms for the region like the Beyond Sustainability Group, which focuses on developing a regional cradle-to-cradle business park with major businesses in the area. Initiatives such as De Groene Kapstok focuses on making schools more sustainable. On the other hand, membership of the EMF positions the city as a leader globally and offers opportunities for knowledge sharing. The interviewee expressed a need to question government subsidies for a more innovative way of financing, "*. . .how do we move from calculating everything to death to challenging people to think about the CE transition?*" (interview, Urban Designer).

4.5. The Hague

The Hague municipal government has developed a sustainability goal to reduce its climate change contribution to zero in 2040 (Gemeente Den Haag, 2015). The city council sees the importance of sustainability, however there is currently low political ownership of the initiative across departments. Nevertheless, The Hague's program manager for sustainability highlighted that they recently created a full new work program, in 2016, to make progress towards its vision. The program manager appointed a new director who has "sustainability in his genes" and who is keen on urban metabolism, allowing them to push the CE agenda from top-down.

An extensive study was performed to determine what would be necessary to make The Hague carbon neutral in 2040. It was found that this would require unrealistic financial resources, so the focus has shifted towards accelerating business initiatives. The program manager there thus sees their role as a facilitator rather than the main 'financier' of CE projects. It sometimes makes investments, but sees that its main role is to mobilise citizens and bigger players in the city. "*[A]nd, if investments exceed their capacity or the timescale is 30 years or so, then the municipality can help*" (interview, Program Manager for Sustainability).

The Hague is yet to formalise a specific vision on CE and has no tangible CE plans or formal strategy despite interest from policymakers there. This means that there are a few enthusiastic policymakers, but their understanding of what CE means for their city is limited, due to the novelty of the concept and a lack of direction in the municipality. The program manager conveyed a need for tangible examples of what a circular city might be, and what kind of activity that includes. They have difficulty understanding what kind of changes they should be making and feel that a future vision of a circular city would help them for a number of reasons: to formulate a direction, to convince senior civil servants of the value of CE and lastly, to communicate to the city's various other stakeholders. They feel that the market is instrumental in moving towards a circular city, but also stress that communicating this is difficult.

4.6. Barcelona

In Barcelona, the city has an ambition to become a self-sufficient region by 2050 and plays a facilitative role to achieve this. Its smart city master plan was initiated top-down and that has included redesigning the transport system, installing smart lighting and installing intelligent heating and cooling systems (Data-Smart City Solutions, 2016). Through large scale implementation initiatives energy, waste and water savings have been realized. More recently (2016), the city mayor and

Table 9
Clustered analysis of projects identified.

City strategy	Policy approach	Identified
Fund entrepreneurs, circular start-ups, and communities working on urban challenges	Business support schemes	A6, A10, A11, A12, H9, H10, R5
Facilitate city level collaborations with (major) urban stakeholders	Business support schemes, collaborative platforms, knowledge development, procurement and infrastructure	A4, A6, A7, A10, R2, R4, R6, R8, H4, H5, H8, H10, G6, G8
Foster visibility of initiatives through networking and publicity	Business support schemes, collaborative platforms, knowledge development	A3, A9, H2, H3, H4, H5, G4, G8, R9, R10
Build public engagement through visioning adaptable urban futures	Knowledge development	G1, G5, R9, R10
Identify and bolster existing initiatives (retrofit buildings, optimize energy systems, accelerate innovative projects)	Procurement and infrastructure, business support schemes, collaborative platforms	A6, A8, A9, A14
Elicit commitments from major urban stakeholders	Collaboration platforms	A5, A7, R4, H4
Facilitate small and large experiments and demonstrator pilots with communities and major stakeholder through e.g. urban living labs	Knowledge development, procurement and infrastructure, collaborative platforms	A3, A6, A8, A15, A17, R1, R3
Build knowledge through educational initiatives, knowledge development, innovation and collaboration platforms	Knowledge development, business support schemes, collaborative platforms	A4, A7, R9, R10, H1, H2, H3, H5, H6, G4, G6, G8
Develop regulations, standards and procurement guidelines to support circular tendering	Procurement and infrastructure, collaborative platforms	A13, A18, A19, H11
Focus on understanding (data gathering and digital scanning) and managing (reuse, industrial symbiosis) resource flows (biomass, water, energy)	Knowledge development, procurement and infrastructure, collaboration platforms	A1, A2, A15, A16, A20, R1, R7, R8, R11, H2, H3, H7, G1, G2, G3, G5

digital commissioner have proclaimed a circular city is one of its four key targets for 2020 (alongside becoming a Democratic, Common and Creative City).

The city's smart and circular initiatives are closely linked. This link can be seen in the Fab City concept that emerged in 2011, led by the urban innovator, Tomas Diez, who proposed a new urban model for sustainable self-sufficient cities through "locally productive and globally connected" means, based on digitally networked Fab Labs. In 2014, the city's then chief architect envisioned the opportunity to build self-sufficient city blocks that could be networked according to mobility, water, waste and heating systems, supported by a network of Fab Labs. This commitment to foster self-sufficiency through a new vision of urban production is an experimental approach. With buy-in from the city's then deputy mayor and through sharing of information (DIDO: Data-In Data-Out) as opposed to resources (PITO: Products-In Trash-Out), its proponents envision ways to harness the benefits of new digital technologies (such as 3D printing) to create goods, with local materials for local needs. The initiative is supported by the Barcelona City Council and proposes to install an ecosystem of private and public Fab Labs in each of the city's regions.

Though the city's high level strategy has emerged from the smart city and this has been initiated top-down, there is a shift to more proactively include citizens as this is seen as a limitation to previous efforts (Kuyper, 2016). The interviewee described how previous city-led initiatives (such as the '*self-sustainable city*') were overly academic and this alienated people, whereas circular is more innovation focused and this makes it appealing. The city has a prominent commons movement that advocates for peer-to-peer and collaborative economy initiatives. For example, a local community (led by the Makea tu Vida[9] collective) has been actively exploring the circular economy (through an open source approach) since 2014. Its mission is to integrate the digital culture movement with the economic will for closed loop material cycles. Through the Barcelona commons movement, citizens have facilitated the development of policy proposals for a collaborative economy, which are under review by the Barcelona city government and have also been sent to the European Parliament. The city's economy is made up of 10% cooperatives, reflecting the uniqueness in the city itself. The self-organizing characteristic of the city is evident "*The citizen is smart and empowered*" and "*the culture is that the citizens will do it*".

4.7. Cross-case analysis

Each of the city cases offer learning points: Amsterdam uses inventive forward-thinking examples of how to experiment with policies; Rotterdam illustrates the importance of long-termism and being pragmatic in establishing plans that supersede policy cycles; Glasgow reflects a business-centric narrative offering the possibilities of 'being really radical' and emphasizes that it is important to know how to engage all stakeholders even if this can be a challenge; Haarlemmermeer reflects how political ownership can drive initiatives; on the other hand The Hague shows how a lack of leadership leaves policymakers

[9] http://www.makeatuvida.net/.

rudderless, connoting a need to be inspired by other cities; Barcelona shows how an initial top-down approach was later adjusted to be more inclusive to citizen and community views.

The cross-case analysis involved analysing projects according to the ReSOLVE framework (Appendix A) and clustering strategies according to similar themes. The list of projects in Table 9 shows the outcome of the cluster analysis. The efficacy of these initiatives has not been evaluated in this study. Therefore, it is not possible to say which strategies are more or less effective. It rather gives an indication of the projects that are viewed key actors as circular initiatives. Moreover, many of these approaches are interlinked and complementary.

We see how policymakers are using a dual approach of *CE broad* and *CE principle specific* initiatives. Those broad, often collaborative public–private partnerships, serve multiple purposes including; to continuously gather information and generate knowledge on CE in the city; encourage business-led innovation; allow policymakers to identify the needs of major urban stakeholders; and also establish connections between these actors. Principle specific projects incentivize partners, businesses and knowledge developers to collaborate on circular products and services. Buy-in from these influential stakeholders is seen as important. Strategies are focused on business innovation for new forms of delivering services and products, whereas less effort and/or support is provided for changing consumer behaviours or investing in community initiatives, even though clear bottom-up citizen- and community-led initiatives have been raised during the research.

Many of the initiatives identified could be seen as incremental, without any clear evidence of major investments to transform incumbent unsustainable industries. Clearly much activity is happening in the frame of generating knowledge and information and conducting baseline research activities. For example, data gathering on a city's physical resource flows can inform large and small scale urban experiments and is observed as a practical starting point for some cities. Interviewees emphasized the importance of accelerating innovation through experimentation. These can be facilitated by policymakers and the focus ranges from self-sufficiency, industrial ecology and 'looping' (waste, food, water) resources on a local level. Legislation like Amsterdam's 'Free Zones', allows exploration of how to implement circular cities and is a tangible example constructed specifically to facilitate CE experimentation. In addition, public engagement attributes of creative urban living labs are championed.

5. Analysis and discussion

This section analyses and discusses the findings according to key themes and states the contribution of the work to inform future research on circular cities.

5.1. Stakeholders in a circular city

5.1.1. Businesses

The business-focus of circular city initiatives discussed here is evident in procurement and infrastructure programs that invite and reinforce existing networks and collaborations with 'major city stakeholders' (Table 9). For example, in Scotland the 'technocycle' activity is tailored to the heavy-industry there, which is suited to remanufacturing. In the case of Rotterdam, we see large-scale collaborations with the city port in cooperation with the waste management department and similar examples occur in other cities. Across cases, circular is linked to needing to 'drive' and 'grow' the city's economy to create innovative business. It is included in the Glaswegian manufacturing strategy and in Haarlemmermeer the sustainability department workers view the 'market' as critical. This gives rise to many large public-private partnerships. Several cities use business support schemes and collaboration platforms (Haarlemmermeer, Rotterdam, Amsterdam, Glasgow), for example, to learn how they can legislatively assist "the middle section" of businesses, once these experiments have developed initial know-how. Similarly, the emphasis of work within the Glaswegian chamber of commerce reflects the motive to further 'circular' as a business interest. Business support schemes for start-up, micro and small business beneficiaries, that accelerate bottom-up circular innovation, are also used to create the market.

One of the many reasons for this is that city policymakers describe issues with financing circular innovation in cities and supporting business-led innovation is seen as a way to partially overcome this barrier. This is reflected in how circular is communicated, "*it has huge economic benefits as well so it's not one-dimensional. . .it's big and inclusive*". However, sometimes the views conveyed are traditional and indicate an unclear focus on the need for urban sustainability to be addressed: "*How do you grow a city's economy and benefit the city through circularity*". However, the emphasis is on powerful industrial partners who have influential agendas with local governments and this can be a risk to progress on urban sustainability due to vested interests (e.g. incineration plants contracted by local councils in the UK).

5.1.2. Public sector

Senior civil servants (e.g. alderman/city mayors) are seen to establish initiatives and forge high level strategy documents. Notwithstanding the development of such strategies, weak governance structures have been identified in some cities, where the success of initiatives is beholden to individual actions and therefore susceptible to short-termism/political motivations. On the contrary, in the case of Haarlemmermeer, the city's policymakers described having difficulty leveraging local government support for their ideas. They reflected how visual representations and concrete examples could aid this. A need for visibility is seen as key to cross-fertilizing ideas for innovation and to inform policy decision-making. Interviewees describe how high profile visioning exercises serve multiple purposes: by setting the city direction, convincing senior civil servants

and also fostering public awareness of circular city initiatives. This is seen as important in this study and has also been identified as a barrier to CE in other studies (Geng et al., 2009).

Low ownership is likely to lead to future failure. However, other issues are identified too. Municipalities see themselves as 'facilitators rather than financiers' and are reluctant to invest in new infrastructure to replace incumbent unsustainable systems (e.g. energy) as this is seen as too expensive. Therefore, real and ambitious plans to overhaul resource systems are delayed, as in the case of Glasgow, where the interviewee says the city 'could be really radical', betraying the reality that this is unlikely. In addition, interviewees see visioning exercises as a way to make cities *future-proof*, but many cities find this challenging due to political time-constraints. This has been raised in the past as a challenge to a systemic shift towards urban sustainability (Loorbach and Shiroyama, 2016). For instance, in the Netherlands (as is the case in many cities), the city council is re-elected every four years and strategies are made for this timeline. In contrast, Rotterdam and The Hague municipalities plan for four-year cycles, but also put resources into creating long-term future visions. There, the city invokes its experience of creating ambitious future urban plans[10] and leverages the large creative force in the city to co-create an inspiring future vision. Rotterdam works with a roadmap towards that vision with projections of 30 years into the future. This has led to CE- and bio-economy project plans that have long-term goals.

5.1.3. Knowledge institutes

Policymakers develop or participate in 'CE broad projects', to cultivate knowledge and clarity on urban CE as a starting point for their initiatives. Building knowledge of what CE means at the city-level is seen as fundamental due to the current lack of clarity on the concept. Universities and consultancies with specialist expertise are key partners, for example in developing data sets about resources and how they can be managed and building a broader understanding of what a CE would mean on a city scale. This is a starting point for further policy making. For instance, in Amsterdam and Glasgow, activities that involve baseline research into resources are seen as fundamental to informing next steps. Furthermore, expertise in specific aspects of CE is seen in the Scottish Institute of Remanufacturing set-up in Glasgow. These partnerships range from specific activities, to more experimental set-ups supporting the development of knowledge on what urban CE means, through research, collaboration and experimentation as well as to encourage and develop CE projects developing from the bottom-up in their city. Policymakers are spending time unpacking what CE and sustainability mean to their own city context and what they 'should be doing', suggesting that the development of the circular city concept is still under development.

5.1.4. Citizens and communities

In each of the cases we see various considerations of the citizen's quality of life and wellbeing, as well as the need for citizen behaviour change. For example, in the case of Haarlemmermeer, the policymaker stresses the need for inclusion of the "citizen" through the "quadruple helix". Equally, in Glasgow considering citizens and communities in developing a city's future vision is conveyed as important, yet challenging. Here, policymakers can learn from each other. For instance, examples of emergent community-led (through charities and voluntary groups) initiatives have been identified during the research such as De Ceuvel (Amsterdam), Blue City (Rotterdam), Open Source Circular Economy (Barcelona) that can foster public awareness and engagement.

However, there are also inconsistencies in the approaches described. Some of the interviewees (policymakers, urban innovators) convey an inclusive future-oriented view. While citizens and community voices are espoused as important, policy measures tend not to reflect this (Table 9), emphasizing 'major' business stakeholders or data-driven knowledge development activities (urban material flows, city scans, data platforms). Similarly, we see recognition of the need for citizen participation in governance (quadruple helix). However, only after-the-fact are citizens engaged, where a more participatory approach could involve citizens from the outset. This is also important because, to address priority elements (Ghisellini et al., 2015; Riisgaard et al., 2016) of the CE (food waste, repair, reuse) citizen and public engagement is critical. This is reflected in the case of Barcelona, which initiated a top-down approach but later revised its strategy to foster more citizen inclusion (Kuyper, 2016).

5.2. Perspectives on circular cities

5.2.1. Risks of conflating circular with sustainable

City policymakers are grappling with the ambiguous relationship between the concepts of circular cities and sustainable cities and are unable to clearly articulate this relationship. The concepts are often used in the same context, and most cities' CE plans are part of a sustainability plan. "*Cities of the future are not sustainable without circularity. The cities of the future will be cities that are circular*". Rotterdam's sustainability agenda has three main ambitions and creating a CE is one of five ways to work towards one of those ambitions (Gemeente Rotterdam, 2015). In Amsterdam on the other hand, the sustainability agenda outlines five goals, one of which is CE. Here CE is considered a *goal*, along with clean air, renewable energy, a sustainable city and a climate resilient city (Municipality of Amsterdam and Department of Urban Planning and Sustainability, 2015). Furthermore, cities are observed to retrofit initiatives under a CE label so they become part of the

[10] Rotterdam has a strong culture of extensive future urban planning due to the city being bombed in the 2nd World War.

Table 10
Example excerpts illustrating the undefined relationship between CE and sustainability.

Example excerpts illustrating the undefined relationship between CE and sustainability
E12: "[Sustainability] is really the integrated vision for the agenda, or the overarching theme, so a circular city or a CE is also about renewable energy, clear air and dry feet."
E13: "Because circularity is also seen as the 'new sustainability' but it is really still about people, planet, prosperity, but there is really a type of stratification there."
E14: "[Our sustainability agenda] contains a lot of mobility, housing, retrofitting, I'll just call that normal sustainability for a moment, and not circularity, at least. . .yes, that is how I'll define that."
E15: "I guess it's about how broad you define circular, I think we have a more narrow definition, well I mean we do circular in the broad sense, but something like the district heating dossier, it's such a big project, it is just its own project within sustainability."
E17: "We established that we were having a lot of discussions: should circular be above sustainability or the other way around? For me it is the same, it's nothing new."

Table 11
Excerpts illustrating the different positions on urban CE.

Perspective	Example excerpt
CE is an end goal to work towards (of a sustainability agenda)	E5: "So it might actually be our ultimate goal" E9: "Our mission is that we want to start doing something with it [CE]."
CE is a means to an end	E6: "So we had a discussion, [. . ..] why should you want to measure CE, because it is nothing more than a means, to create a liveable, resilient, future-proof city."
CE is a subset/aspect of a smart city	E7: "We consider circular to be a part of smart city, because smart city is a broad concept, circular is kind of niche."
Any definition of the future is difficult, including a Circular City, because of uncertainty of the future	E3: "And if I think, what would really help me? It's a future picture, like a written story or something, a day in 2033, what would that look like?" E4: "[T]here's no point in going out there when you don't have a real engaging motivating vision of what it could look like and what the benefits are."

circular city strategy (e.g. renewables target in Scotland existed prior to its CE work). This means that many of the projects described could previously be labelled a sustainable city initiative. However, while sharing initiatives (for example) can be beneficial to the environment, by reducing transport, this is not unequivocally the case (Cohen and Muñoz, 2016). This means the concept of the circular city needs critical reflection as well as measures and indicators to evidence progress towards urban sustainability.

Table 10 provides insights into interpretations of this relationship among interviewees illustrating the broad range of meanings cities have attributed to CE through their agendas and strategies. In many cities, sustainability is an umbrella-concept that has a broad interpretation among policymakers. Similarly, wide-ranging views have been conveyed by policymakers in this study. This raises questions about the long term trajectory and implementation of circular cities and the risks of conflating 'circular' with 'sustainable'. Such escalation of meaning is unproductive and works against cities' progress.

5.2.2. Defining circular cities

The typically broad view of the circular city discussed in Section 5.2.1 is reflective of how interviewees themselves perceive a circular city. The CE concept is variously co-opted into smart city visions and sustainability strategies. Policymakers are struggling with understanding the conceptual aspects of (urban) CE and each has a unique viewpoint on its meaning, ranging from it being a strategic ambition (effectively a contemporary sustainability vision) to it being a niche concept subsumed in the smart city phenomenon. Or, it is seen as a means to an end (a tool), yet that end is unclear. All this coalesces to fragment urban sustainability initiatives and make the concept ambiguous. This can be seen in how, for example, the policymakers in The Hague are enthusiastic about CE but lack understanding of what to do. Table 11 shows such diverging views.

Policymakers have difficulty grounding the concept of CE in day-to-day practices. The range of views is symptomatic of the ambiguity about what circular is and is not. A clearer understanding of CE and its manifestations in a city is needed to initiate impactful CE projects effectively and in-line with a given city's overarching future strategy (Kennedy et al., 2011). In addition, urban sustainability is about resilience and livability beyond the city's infrastructure and technology. In light of this, the concept a circular city can be seen as an element in the larger goal of developing a future-proof city. This means that a circular city is a city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city.

5.3. Contributions, limitations, further work

5.3.1. Contributions

In this study, we have undertaken initial exploratory research into the concept of a circular city. This has led to the development of a circular city framework, six cases exploring this emergent topic, a definition of a circular city, as well as identifying a set of strategies that city managers are using. The framework, definition, cases and strategies described in this study can act as a starting point for further work on this topic.

5.3.2. Limitations

The CE transition is a relatively new undertaking and so these observations apply to the early stages of this transition in early stage cases. The circular city framework (Fig. 1), adapted from the ReSOLVE Framework (EMF, 2015), was validated by participants and experts and was a useful tool to engage policymakers in the CE discussion. However, while it is useful to map existing initiatives, the contribution of these initiatives to urban sustainability has not been evaluated. Furthermore, questions remain about whether or not some of the projects (e.g. sharing economy) and the cities studied in this article, that host globally significant ports (e.g. Schiphol airport, Rotterdam port), can ever truly become future circular cities.

This research focused on small, high income, evenly populated, relatively prosperous cities, so the sample is limited in its diversity. Although this facilitates cross-case analysis, this does not represent the different types of cities globally. The urban challenges faced in other regions may vary substantiallyIn particular the strong links to digital baseline activities (smart cities) that can inform circular cities may mean other cities, with less access to technology, would likely have a different starting point.

5.3.3. Further work

This study has raised a number of areas for further work: Does the broad viewpoint conveyed by city managers undermine circular as a long-term strategy for urban sustainability? What tools, methods and tangible examples can be developed to lead city managers towards a holistic implementation of circular cities? How can CE be used effectively as a future city perspective (ultimate goal, driver etc.)? How can policymakers better support citizen and community initiatives? In the absence of investment in new infrastructure (e.g. renewable energy) to replace incumbent unsustainable systems, can cities truly become circular?

6. Conclusions

The aim of this paper was to explore how city managers are implementing circular city initiatives: *How are cities adopting CE as a strategy?* The research identified a set of common policy approaches being used to implement circular city practices across the cases studied (Table 9).

Political leadership of the agenda, consideration of the city's context as well as engagement with all of the city's urban stakeholders are identified as important. This is because, business engagement is used as a way to overcome financial barriers to implementing a CE that local governments may face and citizens and communities are seen to develop self-sufficiency initiatives from the bottom-up. We also found that having a long-term adaptable vision and using experimentation to try to unravel the circular city concept are utilised: this ranges from legislative 'free zones' to public facing circular urban living labs.

From a transition perspective, a future CE requires a considerable change in how society consumes, as well as investments in infrastructure, to transform existing unsustainable (waste and energy) infrastructure. In this study, city policymakers are seen to be keen to include the CE within their agendas. However, in reality policymakers are unclear on what a circular city constitutes and express the challenge of untangling a coherent picture of what a circular city means in practice. This leads to ample activities focused on developing baseline knowledge on the CE in cities. In addition, policymakers rely on businesses to lead the implementation, choosing to use affordable experiments and business incentives, including collaboration platforms, financial mechanisms and knowledge development approaches. Furthermore, while the role of citizens and communities is revered, there appears to be a mismatch in how these stakeholders are included in building a circular city vision. Rather emphasis is placed on major urban stakeholders, as well as digital and data-driven approaches from the outset of developing policies.

This approach raises the concern that, if implemented poorly, compelling sustainability concepts (as the CE is) can lose credibility and become reduced to buzzwords or greenwashing. This means that the scientific community has to ask the question of what a sustainable circular city looks like and has a responsibility to provide clear guidelines and advice to policymakers as to how to approach this new agenda. Here we find that a circular city is a city that practices CE principles to close resource loops, in partnership with the city's stakeholders (citizens, community, business and knowledge stakeholders), to realize its vision of a future-proof city. Notwithstanding this, the 'circular city' concept is open for debate and provides an opportunity to work with enthusiastic city managers towards a legitimately sustainable urban future.

Finally, this research has some limitations. While mapping of current policy strategies is insightful for other cities and future research, further work is likely to identify strategies that go beyond those identified here. The initiatives identified for each city are not intended to be exhaustive but rather provide insight into how a circular city emerges and the range of activities underway.

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Appendix A. Overview of all projects per case

This appendix provides an overview of all the projects used in this research in mapping, framework development and analysis. For reference, they are all explained here very briefly.

Project code	Project name	Explanation	Project type	Identified through	ReSOLVE criteria
A1	Circle Economy City Scan	CE consulting firm Circle Economy has performed an extensive CE scan for the city mapping current waste and resource flows and identifying promising CE areas.	Knowledge development	Interviewee (Eveline Jonkhoff, Jurn de Winter)	L
A10	Sustainability Fund	Government fund available to entrepreneurs developing sustainable initiatives or businesses in Amsterdam.	Business support schemes	Interviewee (Eveline Jonkhoff)	ReSOLVE
A11	Amsterdam Economic Board	Government initiative with purpose to rapidly develop start-ups and businesses in Amsterdam if they contribute to several outlined urban challenges.	Business support schemes	Interviewee (Sladjana Mijatovic)	ReSOLVE
A12	CTO Office Start-up in residence	City government offers start-ups that have developed solutions to societal problems the chance to develop their idea and possibly sell to the city as a client.	Business support schemes	Interviewee (Sladjana Mijatovic)	ReSOLVE
A13	Sharing economy legislation	Amsterdam government has developed legislation that supports Sharing economy initiatives like Uber and Air B'nB.	Business support schemes/legislation	Interviewee (Sladjana Mijatovic)	S
A14	Retrofitting buildings	Retrofitting monumental buildings in order to increase their energy efficient.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	OE
A15	Alliander "SmartGrid"	Project by Alliander (grid-operator) to develop Smartgrids, supported by city as experiment.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	OE
A16	District Heating	Large scale district heating using heat from industrial area and port.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	L
A17	Free-zones	City has developed legislative "free-zones" where partners can experiment with waste collection, water sanitation etc.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	ReSOLVE
A18	Building renovation standards	Learning from the Green Deal, policymakers are working on developing regulatory standards for circular building renovation.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	OE
A19	Circular Procurement	Policymakers are working on developing a decision tree for procurement employees enforcing circular procurement policy.	Regulatory framework	Interviewee (Sladjana Mijatovic)	E
A2	City dashboard	In development: dashboard monitoring CE development	Knowledge development	Interviewee (Eveline Jonkhoff)	V
A20	Household Wasteplan	Extensive household waste management in cooperation with waste-industry stakeholders.	Procurement and infrastructure	Interviewee (Eveline Jonkhoff)	L
A3	"Pakhuis de Zwijger"	Independent public knowledge development center, organizes lectures and seminars.	Knowledge development	Desk research	ReSOLVE

A4	AMS Institute	Research institute dedicated to development of sustainable metropolitan solutions, partnership of three universities.	Knowledge development	Interviewee (Eveline Jonkhoff)	ReSOLVE
A5	Construction Greendeal	Declaration of intent between stakeholders throughout construction industry to develop CE in their practices.	Collaboration platforms	Interviewee (Eveline Jonkhoff)	LE
A6	"Circular Buiksloterham"	Large real estate development in the north of Amsterdam where stakeholders in the development have agreed to implement CE solutions where possible.	Collaboration platforms	Interviewee (Eveline Jonkhoff)	ReSOLVE
A7	MRA Industrial Park	Cooperation between stakeholders throughout metropolitan area, dedicated to sustainable development and industry needs.	Collaboration platforms	Interviewee (Eveline Jonkhoff)	ReSOLVE
A8	"The Ceuvel"	Completely circular community development, providing a breeding ground for cultural and creative entrepreneurs.	Collaboration platforms	Interviewee (Sladjana Mijatovic)	ReSOLVE
A9	Amsterdam Smart City	Platform for Optimize-type projects initiated by entrepreneurs or businesses. Offers networking and publicity.	Business support schemes	Interviewee (Emma van der Veen)	O
G1	Future City Glasgow	Data collection and visualization platform for the optimization of Glasgow.	Knowledge development	Interviewee (Nick Boyd)	ReSOLVE
G2	City dashboard	Part of Future City, dashboard monitoring development of sustainable projects.	Knowledge development	Interviewee (Nick Boyd)	OV
G3	Circle Economy City Scan	CE consulting firm Circle Economy has performed an extensive CE scan for the city mapping current waste and resource flows and identifying promising CE areas.	Knowledge development	Interviewee (Nick Boyd, Jurn de Winter)	LV
G4	Scottish Resources conference	Annual conference on resource efficiency in Scotland.	Knowledge development	Interviewee (Nick Boyd)	ReSOLVE
G5	Open Glasgow	Funded by the UK Technology Strategy Board, Open Glasgow is platform for the development of a Smart city in Glasgow, should provide data to entrepreneurs, industries and businesses to allow them to create circular/smart opportunities.	Knowledge development	Interviewee (Nick Boyd)	ReSOLVE
G6	Green Glasgow	City council initiative that clusters sustainable city projects.	Collaboration platforms	Interviewee (Nick Boyd)	ROE
G7	Scottish Institute for remanufacture	Government funded institute with three goals: increase innovation through stimulating and co-funding collaborative projects between industry and HEIs, increase activity and engagement from the academic community to build capacity, and establish the Scottish remanufacturing community.	Collaboration platforms	Interviewee (Nick Boyd)	ReSOLVE
G8	Zero Waste Scotland	Government funded platform that supports and enable circular business development, informs policy development and motivating individual behaviour.	Business support schemes	Interviewee (Nick Boyd), Desk Research	L

H1	"Groen in de klas"	Education project teaching children about plants and their contribution to our biosphere.	Knowledge development	Interviewee (Joost Faassen)	R
H10	ENGINN incubator	Connects (circular) start-ups to important stakeholders and possible partners in the region.	Business support schemes	Interviewee (Joost Faassen)	ReSOLVE
H11	Circular Procurement	Development of guidelines for circular procurement and circular tendering.	Procurement and infrastructure	Interviewee (Joost Faassen)	E
H2	Bio-based expo center	BBE expocenter showing different bio-based economy projects and a place for students to develop their own projects and ideas.	Knowledge development	Interviewee (Joost Faassen)	L
H3	Arizona State University partnership	Joint research project researching CE and sustainability in urban areas.	Knowledge development	Interviewee (Joost Faassen)	ReSOLVE
H4	Beyond Sustainability Group	Large scale collaboration between city and Schiphol Airport Group for the development of a sustainable metropolitan area.	Collaboration platforms	Interviewee (Joost Faassen)	ReSOLVE
H5	EMF membership	CE100 membership, network for CE developing regions, companies.	Collaboration platforms	Interviewee (Joost Faassen)	ReSOLVE
H6	"De groene kapstok"	Similar to "Groen in de klas", projects developed to educate children on the importance of ecosystem health.	Collaboration platforms	Interviewee (Joost Faassen)	O
H7	Greendeal "was&gewas"	Commitment to development of biomass- and biofuel crops and vegetation.	Collaboration platforms	Interviewee (Joost Faassen)	L
H8	SHARE Haarlemmermeer	Collaboration between large real-estate developers in region, committed to developing sustainably.	Collaboration platforms	Interviewee (Joost Faassen)	ReSOLVE
H9	"Meermaker" participation fund	Government fund for sustainable projects and entrepreneurs.	Business support schemes	Interviewee (Joost Faassen)	ReSOLVE
R1	Green waste streams	Pilot project to learn about re-use of small green waste collected by city landscaping services.	Knowledge development	Interviewee (Peter Verschoor)	L
R10	Jeremy Rifkin future vision	Economist Jeremy Rifkin was commissioned to develop a future vision for the city of Rotterdam.	Knowledge development	Interviewee (Peter Verschoor)	ReSOLVE
R11	Better Future Factory	Sustainable innovation and engineering studio, turning waste streams into innovative solutions.	Business support schemes	Interviewee (Peter Verschoor)	ReSOLVE
R2	Biobased Delta	Metropolitan area cooperation between horticulture, greenhouse industry and port for a bio-based delta.	Collaboration platforms	Interviewee (Peter Verschoor)	ReSOLVE
R3	Blue City	Experimental community owned project where small entrepreneurs share biological nutrients in an repurposed public swimming pool.	Collaboration platforms	Interviewee (Peter Verschoor)	ReSOLVE
R4	Rotterdam Climate Initiative	Large collaboration platform between City Council, the Port of Rotterdam and the Rotterdam Environmental Service and works towards a sustainable port and city.	Collaboration platforms	Interviewee (Peter Verschoor)	ReSOLVE
R5	City Lab 010	City government funding project for innovative projects, often CE projects.	Business support scheme	Interviewee (Peter Verschoor)	ReSOLVE
R6	Circularity Center	Cooperative between large financial, industrial and technology partners to accelerate circular business.	Business support scheme	Interviewee (Peter Verschoor)	ReSOLVE

R7	"Project RoSA"	Large scale waste-water looping project.	Procurement and infrastructure	Interviewee (Peter Verschoor)	L
R8	District Heating	Large scale district heating project using heat form Port of Rotterdam industrial area.	Procurement and infrastructure	Interviewee (Peter Verschoor)	R
R9	IABR Metabolism	Bi-annual architectural exposition that allows architects to envision the future of Rotterdam.	Knowledge development	Interviewee (Peter Verschoor)	L

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